

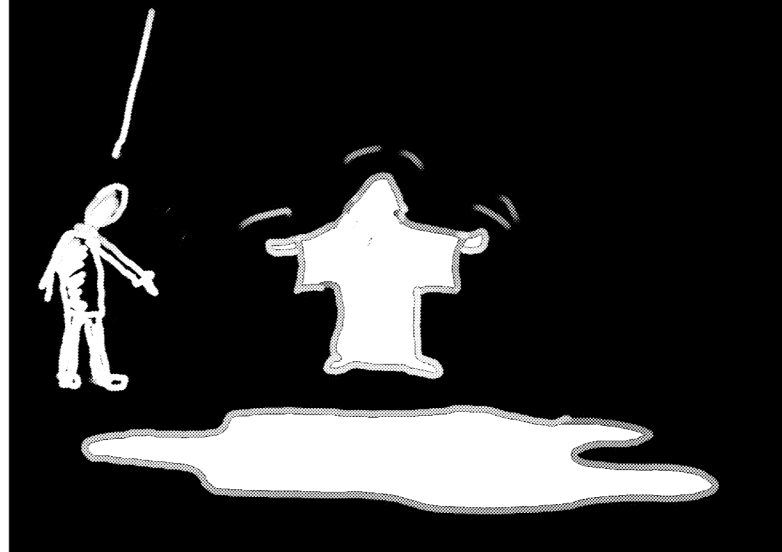
UH... WE'VE BEEN WALKING THE  
WRONG DIRECTION FOR ALMOST  
AN HOUR...I NEED TO GET HOME!  
I HAVE A TEST TOMMORROW!



DON'T WORRY. YOU'LL BE BACK  
IN TIME FOR YOUR TEST. ANYWAY,  
WE'RE HERE!



WE WALKED AN HOUR TO SEE A  
MUD PUDDLE?



MUCH MORE THAN THAT!



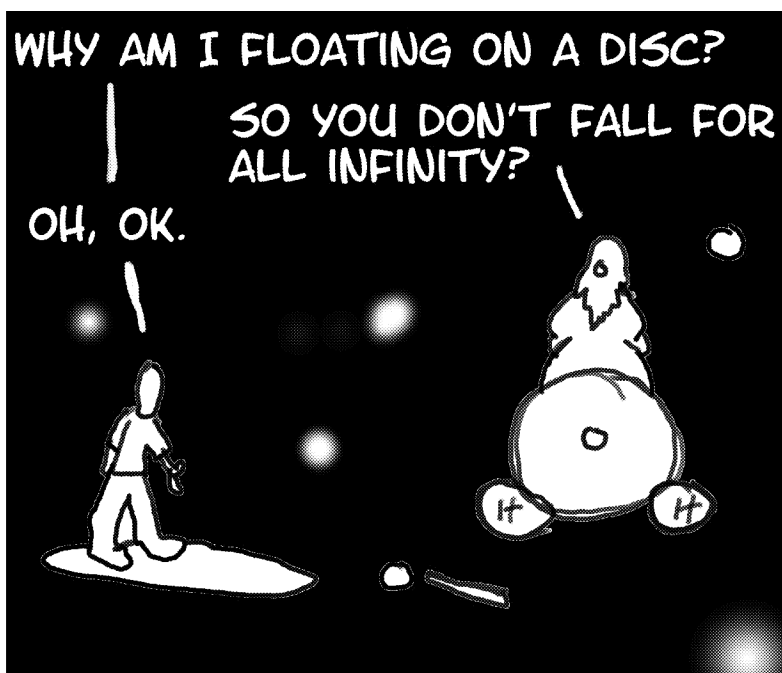
WHAT THE...?



WHY AM I FLOATING ON A DISC?

SO YOU DON'T FALL FOR  
ALL INFINITY?

OH, OK.



WITHOUT WATER, LIFE CAN NOT EXIST.  
THE QUESTION IS.. WHY WATER?

IN ORDER TO ANSWER THIS THIS QUESTION,  
WE NEED TO UNDERSTAND A LITTLE BIT OF  
BASIC CHEMISTRY FIRST.

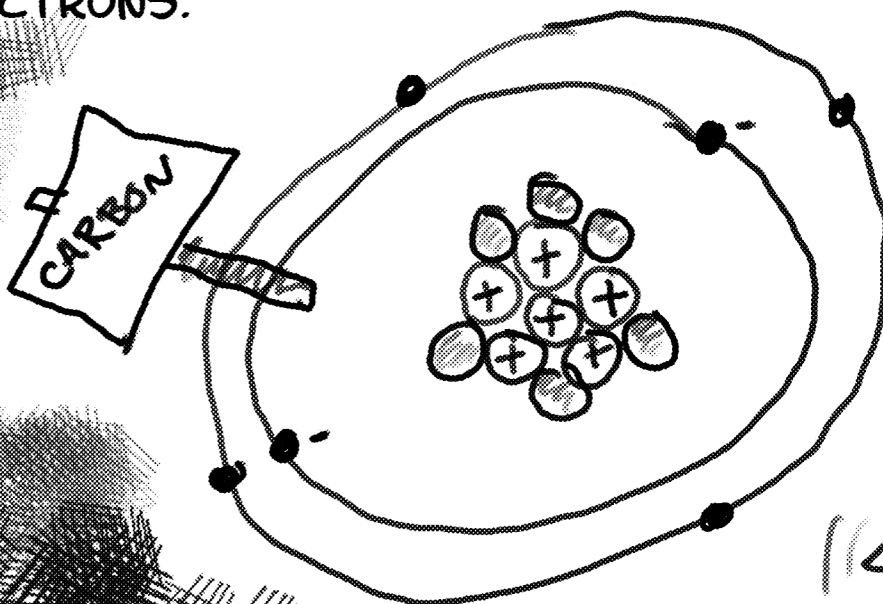
ATOMS: ATOMS ARE THE  
SMALLEST UNIT OF AN ELEMENT.  
IN BIOLOGY, THERE ARE ONLY A HANDFUL  
OF ELEMENTS THAT WE CARE ABOUT:

SULFUR, PHOSPHORUS, OXYGEN, NITROGEN,  
CARBON AND HYDROGEN (SPONCH)  
MAKE UP 99% OF LIVING THINGS.



HERE - LET'S TAKE A LOOK AT AN ATOM UP CLOSE:

THIS IS CARBON, THE MOST IMPORTANT ELEMENT FOR LIFE.  
IT IS MADE UP OF THREE PARTS: PROTONS, NEUTRONS AND  
ELECTRONS.



⊕ = PROTON  
⊙ = NEUTRON  
• = ELECTRON



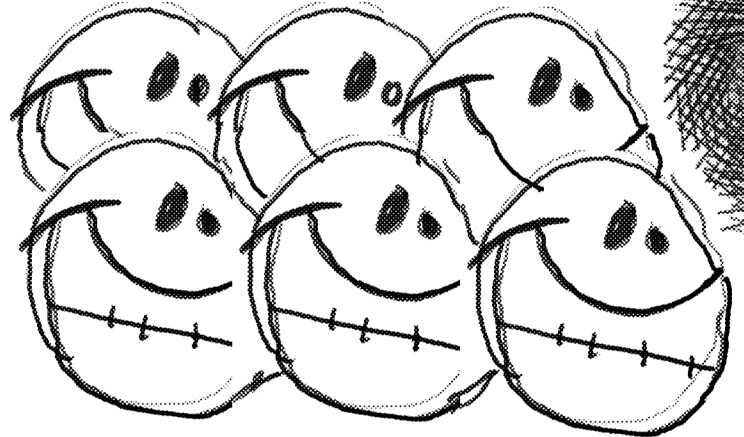
DISC OUT OF CONTROL!  
GONNA PUKE!

PROTONS HAVE A POSITIVE CHARGE, JUST LIKE THE PLUS END OF A BATTERY. THEY HANG OUT IN THE NUCLEUS, IN THE CENTER OF THE ATOM. THE NUMBER OF PROTONS IN AN ATOM DEFINES THE ELEMENT. CARBON, FOR EXAMPLE, ALWAYS HAS 6 PROTONS.

VERY  
POSITIVE  
PROTON

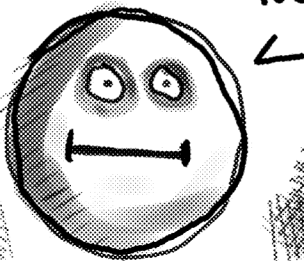


CARBON



ALSO IN THE NUCLEUS ARE NEUTRONS. THEY HAVE ABOUT AS MUCH MASS AS PROTONS, BUT THEY DON'T HAVE A CHARGE. THE NUMBER OF NEUTRONS CAN VARY FROM ATOM TO ATOM. MORE ON THAT LATER.

NOTHING EXCITES ME. EXCEPT DUBSTEP



LASTLY WE HAVE ELECTRONS. THEY ARE HYPERACTIVE LITTLE BUGGERS THAT ORBIT AROUND THE NUCLEUS. THEY HAVE A NEGATIVE CHARGE, BUT VIRTUALLY NO MASS... MAKES THEM VERY HARD TO CATCH!

EASY.... EASY...



BONK!

WEE!



YOU CAN TELL SOME THINGS ABOUT AN ATOM BY LOOKING A PERIODIC TABLE LIKE THIS:

1 H 1.008																	2 He 4.003																			
3 Li 6.941	4 Be 9.012															5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180															
11 Na 22.990	12 Mg 24.305															13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.06	17 Cl 35.45	18 Ar 39.948															
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.38	31 Ga 69.723	32 Ge 72.64	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.798	37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc 98	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.6	53 I 126.905	54 Xe 131.29	
55 Cs 132.91	56 Ba 137.33	57-70 Lanthanide series		71 Lu 174.967	72 Hf 178.49	73 Ta 180.948	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.22	78 Pt 195.084	79 Au 196.967	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po [209]	85 At [210]	86 Rn [222]	87-102 Actinide series		103 La 138.905	104 Ce 140.12	105 Pr 140.908	106 Nd 144.24	107 Pm [145]	108 Sm 150.36	109 Eu 151.964	110 Gd 157.25	111 Tb 158.925	112 Dy 162.50	113 Ho 164.930	114 Er 167.259	115 Tm 168.930	116 Yb 173.054	117 Lu 174.967
Fr 88	Ra 88-102	* * *		Lr 103	Rf 104	Db 105	Sg 106	Bh 107	Hs 108	Mt 109	Uun 110			Uuu 111	Uub 112	Uuq 114																				
118 Og 294																																				

\* Lanthanide series

\*\* Actinide series

57 La 138.905	58 Ce 140.12	59 Pr 140.908	60 Nd 144.24	61 Pm [145]	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.925	66 Dy 162.50	67 Ho 164.930	68 Er 167.259	69 Tm 168.930	70 Yb 173.054
Ac [227]	Th 232.038	Pa 231.036	U 238.029	Np [237]	Pu [244]	Am [243]	Cm [247]	Bk [247]	Cf [251]	Es [252]	Fm [257]	Md [258]	No [259]

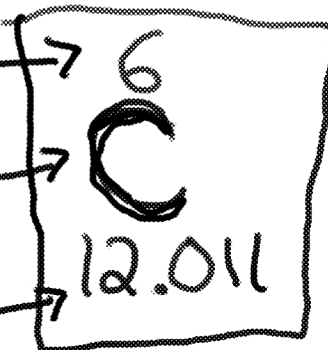


IF WE LOOK SPECIFICALLY AT OUR FRIEND CARBON AGAIN, WE SEE 3 THINGS:

ATOMIC NUMBER

ATOMIC SYMBOL

ATOMIC MASS

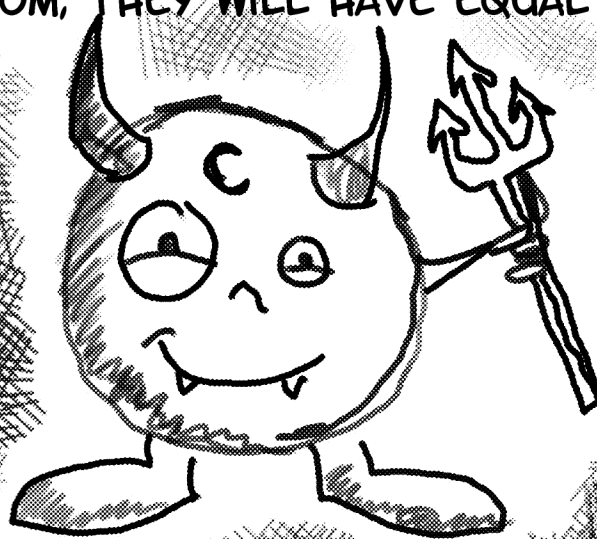


Booyah Boron.

Bye.

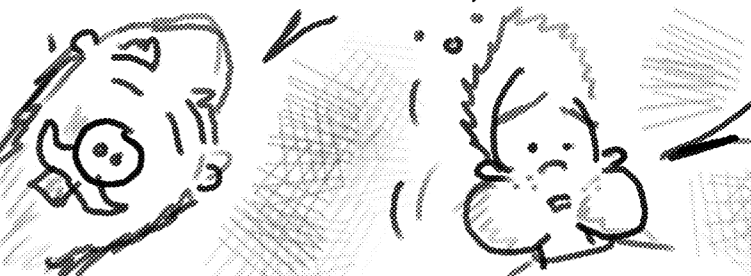
ATOMIC NUMBER IS HOW MANY PROTONS THAT ELEMENT HAS. CARBON IN THIS CASE HAS 6. THE ATOMIC SYMBOL IS JUST HOW IT IS WRITTEN. LASTLY, WE HAVE ATOMIC MASS, PROTONS AND NEUTRONS BOTH HAVE A MASS THAT IS CLOSE TO 1, SO IN BIOLOGY, WE CAN JUST CALL IT 1. THEREFORE, SINCE CARBON HAS HAS A MASS OF ABOUT 12, AND 6 PROTONS, WE CAN FIGURE OUT THAT IT MUST HAVE 6 NEUTRONS AS WELL. IN AN NON-CHARGED ATOM, THEY WILL HAVE EQUAL NUMBERS OF ELECTRONS AS PROTONS TOO.

6 Protons  
6 Neutrons  
6 electrons  
hmm...





NOW, YOU MIGHT HAVE NOTICED THAT CARBON HAS AN ATOMIC WEIGHT NOT OF 12 EXACTLY, BUT OF 12.011.

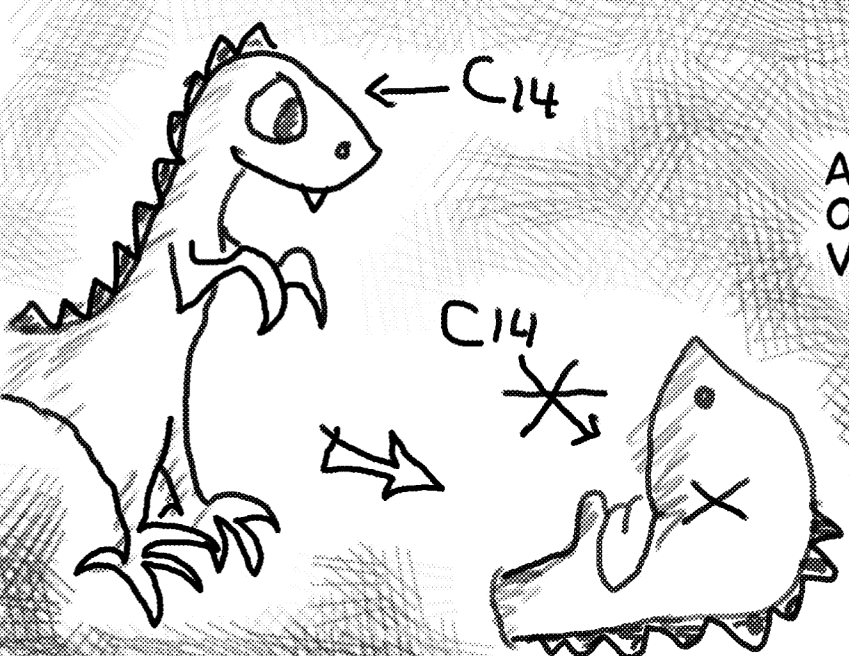


I WOULD HAVE... HAD I NOT JUST THROWN UP ON THE PERIODIC TABLE.

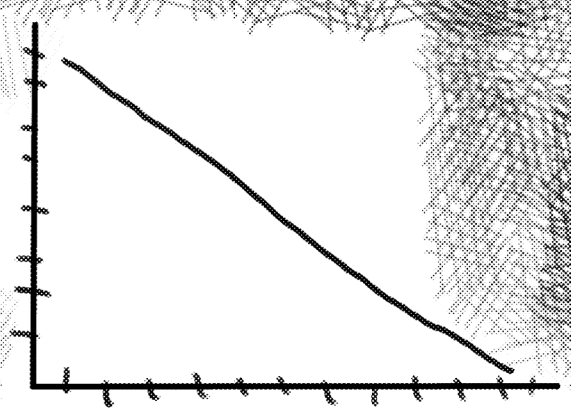
OH, GROSS. THIS DIFFERENCE IS PARTLY BECAUSE IT IS AN AVERAGE MASS OF ALL THE ATOMS OF CARBON KNOWN. SOME OF THESE ATOMS HAVE GREATER OR FEWER NUMBERS OF NEUTRONS. THESE ARE KNOWN AS ISOTOPES, AND THEY ARE USUALLY UNSTABLE AND FALL APART AT A PREDICTABLE RATE.



LIVING THINGS TEND TO TAKE IN LOTS OF A PARTICULAR ISOTOPE CALLED CARBON 14 (HAS 2 EXTRA NEUTRONS). WHEN THEY DIE, THAT CARBON 14 CEASES TO BE TAKEN IN, AND WHAT IS LEFT STARTS TO FALL APART AT A PREDICTABLE RATE. THIS ALLOWS US TO CARBON DATE THINGS THAT WERE ONCE ALIVE TO TELL WHEN THEY DIED.



AMOUNT OF C14 VS C12

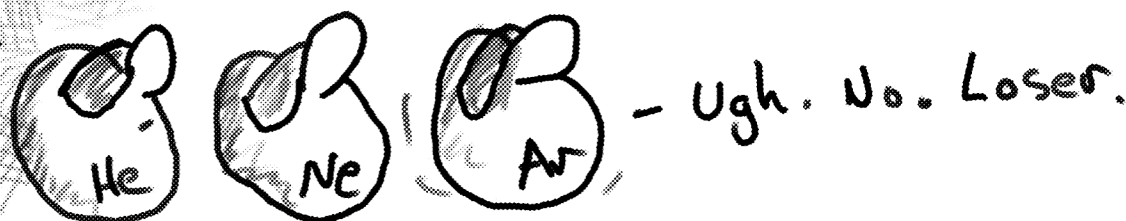


HOW LONG ITS BEEN DEAD

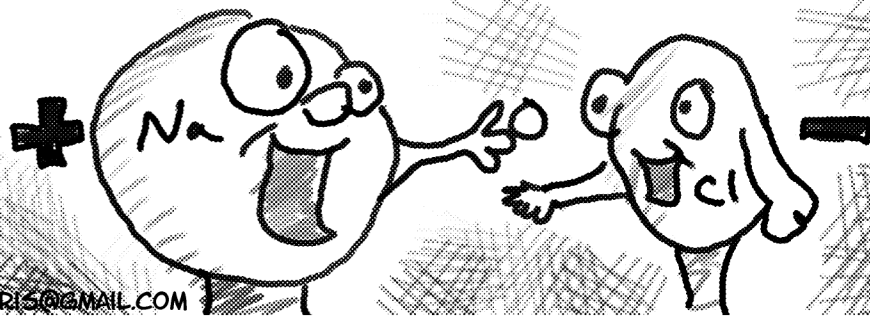
SO HOW THEN DO ATOMS STICK TOGETHER TO FORM MOLECULES? WELL, I'M GLAD I ASKED MYSELF THAT. YOU SEE, MOST ATOMS AREN'T 100% HAPPY WITH THEMSELVES. THEY ARE LOOKING FOR SOMETHING, SPECIFICALLY EITHER TO GAIN OR LOSE SOME ELECTRONS.



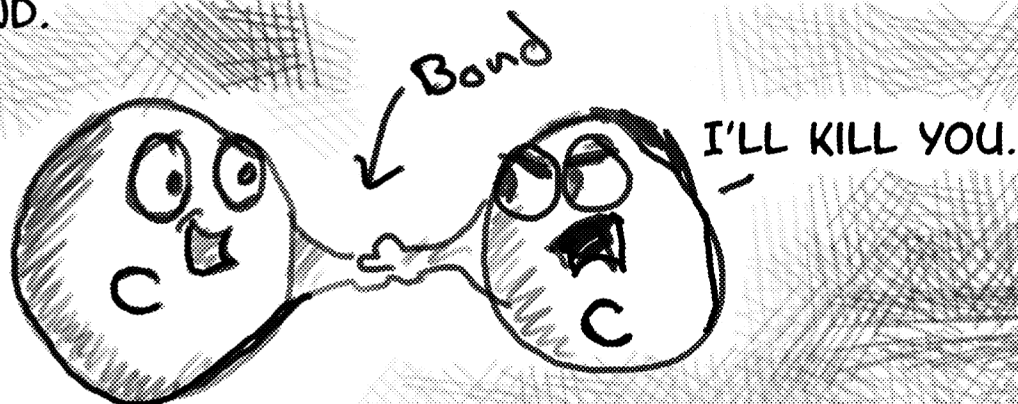
EACH ELEMENT WANTS TO GAIN OR LOSE A CERTAIN NUMBER OF ELECTRONS. THE NOTABLE EXCEPTION BEING THOSE SNOOTY, UPPITY NOBLE GASES IN THE RIGHT HAND COLUMN OF THE PERIODIC TABLE. THEY HAVE ALL THE ELECTRONS THEY WANT, SO THEY DON'T HANG OUT WITH ANYBODY ELSE.



NOW, IF AN ATOM THAT REALLY WANTS AN ELECTRON MEETS UP WITH AN ATOM THAT REALLY WANTS TO GET RID OF AN ELECTRON, THEN THEY FORM WHAT IS CALLED AN IONIC BOND. ONE OF THE MOLECULES BECOMES NEGATIVELY CHARGED (GAINED AN ELECTRON) AND THE OTHER BECOMES POSITIVELY CHARGED (LOST). TABLE SALT, OR SODIUM CHLORIDE IS LIKE THIS.



NOW, IF TWO ATOMS WHO BOTH WANT ELECTRONS THE SAME AMOUNT MEET UP, SAY TWO CARBON ATOMS, THEN THEY AGREE TO SHARE AN ELECTRON, SO THEY ESSENTIALLY BOTH GET 1. THIS IS CALLED A COVALENT BOND.



CAN I SHARE YOUR PORSCHE TOO?

Ed. Note: Atoms don't have cars... unless it's a neon! hoooo!

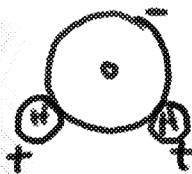
OK, SAME SCENARIO, BUT THIS TIME, ONE OF THE TWO ATOMS IS KIND OF A BULLY. LIKE OXYGEN FOR INSTANCE. OXYGEN REALLY LIKES ELECTRONS, AND HYDROGEN IS KIND OF A PUSHOVER. SO EVEN THOUGH THEY ARE COVALENTLY BONDED (SHARING) THE OXYGEN HOGS THE ELECTRONS A LITTLE MORE THAN THE HYDROGENS, SO IT IS SLIGHTLY NEGATIVE, WHILE THE HYDROGENS ARE SLIGHTLY POSITIVE.



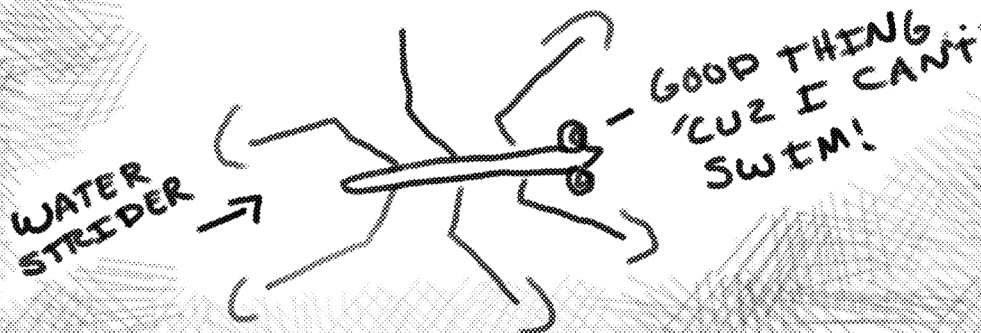
WHY IS THIS IMPORTANT? THIS LITTLE MOLECULAR BONDING QUIRK MAKES LIFE POSSIBLE. IT GIVES WATER ALL THE QUALITIES NECESSARY FOR IT TO BE THE BASIS FOR LIFE ON EARTH. LET'S LOOK CLOSER AT WATER...



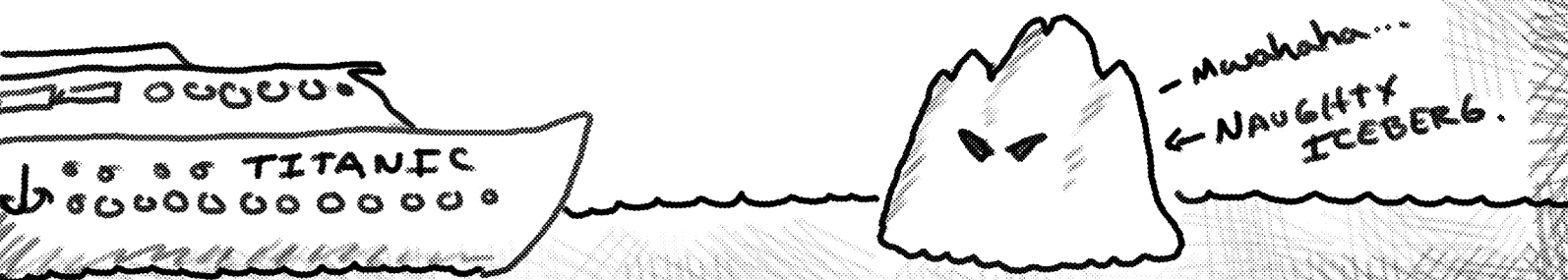
BECAUSE OF THESE SLIGHTLY POSITIVE AND SLIGHTLY NEGATIVE ENDS TO WATER, WE CALL IT A POLAR MOLECULE - AS IN IT HAS POLES, JUST LIKE A MAGNET. AND JUST LIKE MAGNETS, WATER MOLECULES STICK TOGETHER - THIS RESULTS IN QUALITIES LIKE:



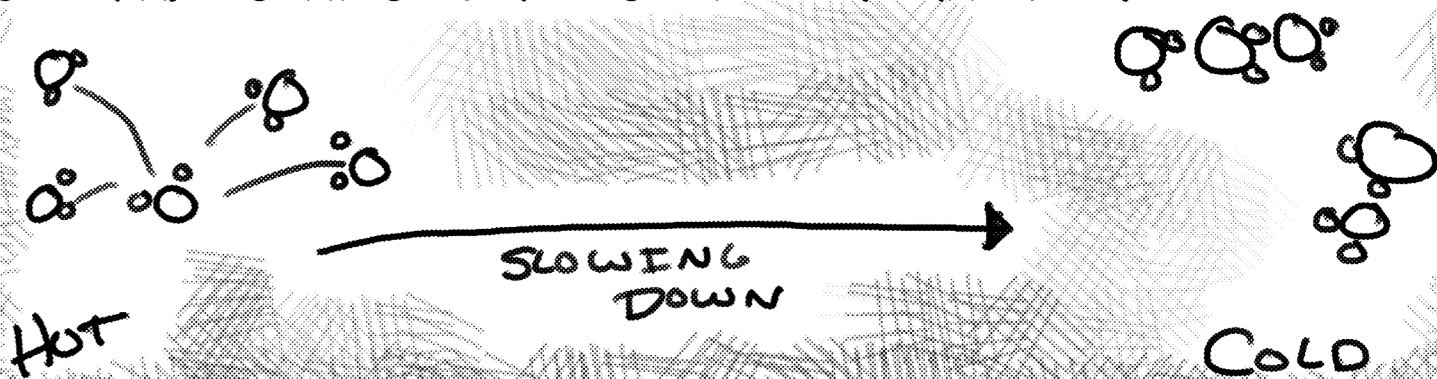
SURFACE TENSION! OR THE IDEA THAT WATER MOLECULES STICK TOGETHER - THIS IS ALSO CALLED COHESION



NOW, ORDINARILY WHEN A MOLECULE COOLS FROM A LIQUID TO A SOLID, IT BECOMES MORE DENSE (MORE WEIGHT PER VOLUME) BUT YOU KNOW FROM EXPERIENCE THAT ICE FLOATS - WHY?



AS WATER MOLECULES COOL DOWN, THEY SLOW DOWN. WHEN THEY ARE WARM (LIQUID), THEY HAVE LOTS OF ENERGY - ALTHOUGH THEY STICK TO EACH OTHER BRIEFLY, THEY QUICKLY BOUNCE BACK. BUT! AS THEY SLOW DOWN, THEY STOP BOUNCING AND START TO STICK AND STAY STUCK: POSITIVE TO NEGATIVE END.

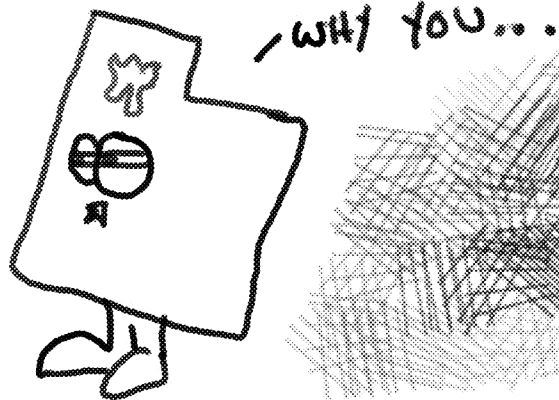
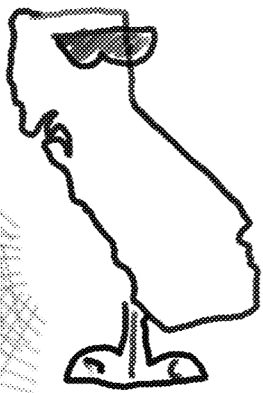




AS MORE AND MORE WATER MOLECULES STICK TOGETHER, THEY FORM A CRYSTAL STRUCTURE (CALLED A LATTICE) THAT IS LESS DENSE THAN LIQUID WATER. THIS IS WHY ICE FLOATS! THIS IS IMPORTANT, BECAUSE WITHOUT THE INSULATING LAYER OF ICE IN THE WINTER TIME, ALL OUR LAKES AND OCEANS WOULD FREEZE SOLID. AND THAT WOULD BE A BUMMER. 'CUZ WE'D BE DEAD.



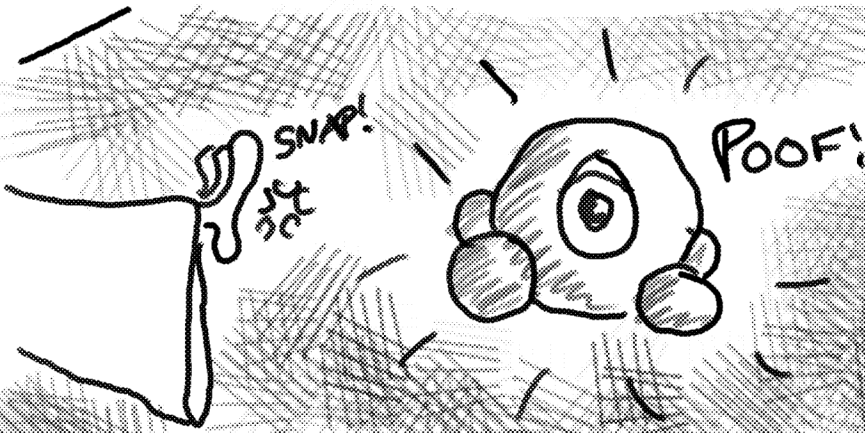
ALONG THE SAME LINES, BECAUSE OF ALL IN THE INTERACTIONS BETWEEN WATER MOLECULES, WATER HOLDS IN HEAT VERY WELL. THIS IS WHY COASTAL CITIES ALWAYS HAVE MORE MODERATE CLIMATES THAN SAY...UTAH. MORE WATER = MORE HEAT AT NIGHT AND MORE COOL IN THE DAYTIME! WITHOUT ALL OF OUR WATER ON EARTH, WE WOULD HAVE HUGE TEMPERATURE FLUCTUATIONS. THAT TOO, WOULD BE AN EARTH KILLING BUMMER.



THE LAST REASON WATER IS SO IMPORTANT IS IT DISSOLVES STUFF VERY WELL (GOOD SOLVENT)- WHICH IS IMPORTANT FOR YOUR INNER WORKINGS. YOUR BODY AND CELLS HAVE TO CONSTANTLY MOVE STUFF AROUND. WATER IS HOW WE DO IT.



THE LAST TYPE OF IMPORTANT MOLECULE IN BIOLOGY IS THE ORGANIC MOLECULE. IN BIOLOGY, ORGANIC SIMPLY MEANS THAT THERE ARE ONE OR MORE CARBON ATOMS IN A MOLECULE. TAKE THIS, THE SIMPLEST OF ORGANIC MOLECULES - METHANE.



WAIT... METHANE... IS THIS WHAT-



MAKES YOUR GAS FLAMMABLE? YES. DON'T TRY IT AT HOME. HAD A GOOD FRIEND WHO LOST A BUTT CHEEK.

OK, WIERD. ACTUALLY I WAS GOING TO ASK IF IT WAS WHAT WE HEATED OUR HOUSES WITH



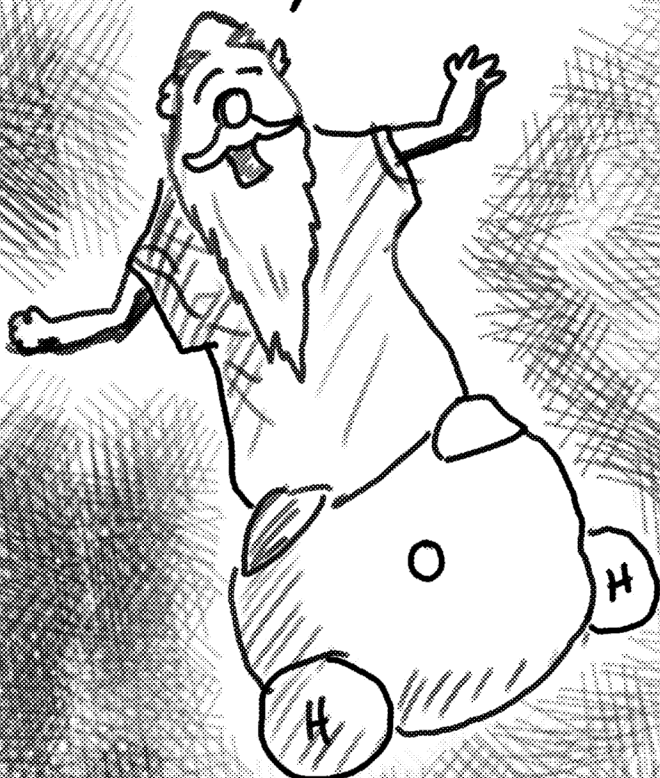
SOMETIMES, BUT USUALLY THAT IS PROPANE, IT HAS A SLIGHTLY MORE COMPLEX STRUCTURE. ANYWAY, ORGANIC = CARBON. GOT IT?

I GOT IT.. HEY THIS LITTLE GUY IS PRETTY AWESOME. CAN I KEEP HIM?





HMMM. I DON'T SEE WHY NOT.  
EVERY BOY NEEDS A PET...  
AHM..GAS MOLECULE, RIGHT?



I THINK I'LL NAME HIM TOOTS.

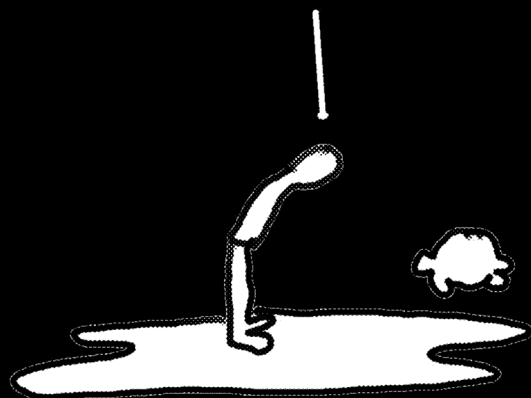


KEEP HIM AWAY FROM  
OPEN FLAMES IF YOU VALUE TOOTS-  
AND YOUR HAIR.

NO OPEN FLAMES. GOT IT. CAN WE  
LEAVE NOW? I THREW UP MY DINNER  
ALREADY, BUT I FEEL LIKE LUNCH  
MAY BE FIGHTING TO COME UP TOO.

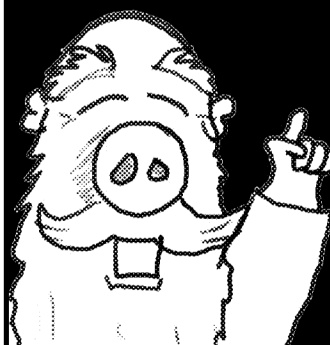


AND NOW I'M STANDING IN A  
MUD PUDDLE AGAIN. THIS NIGHT  
COULD NOT GET ANY INSANER.



MORE INSANE.

WHAT? YOU GONNA TUTOR  
ME IN ENGLISH NOW TOO?



JUST SAYIN'. ANYWAY, WE NEED  
TO GET MOVING TO GET TO CELL  
CITY IN TIME.

IN TIME FOR WHAT?

FOR THE NEXT PHASE OF  
YOUR LESSONS.

ON WHAT?

WELL... NOT GRAMMAR RULES  
THAT'S FOR SURE.

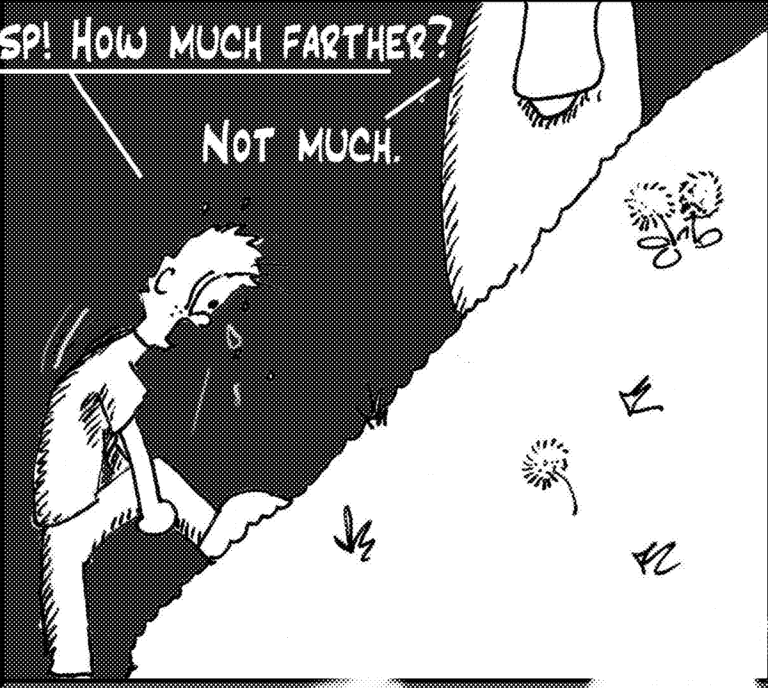
HEY... UH.. WAIT UP!





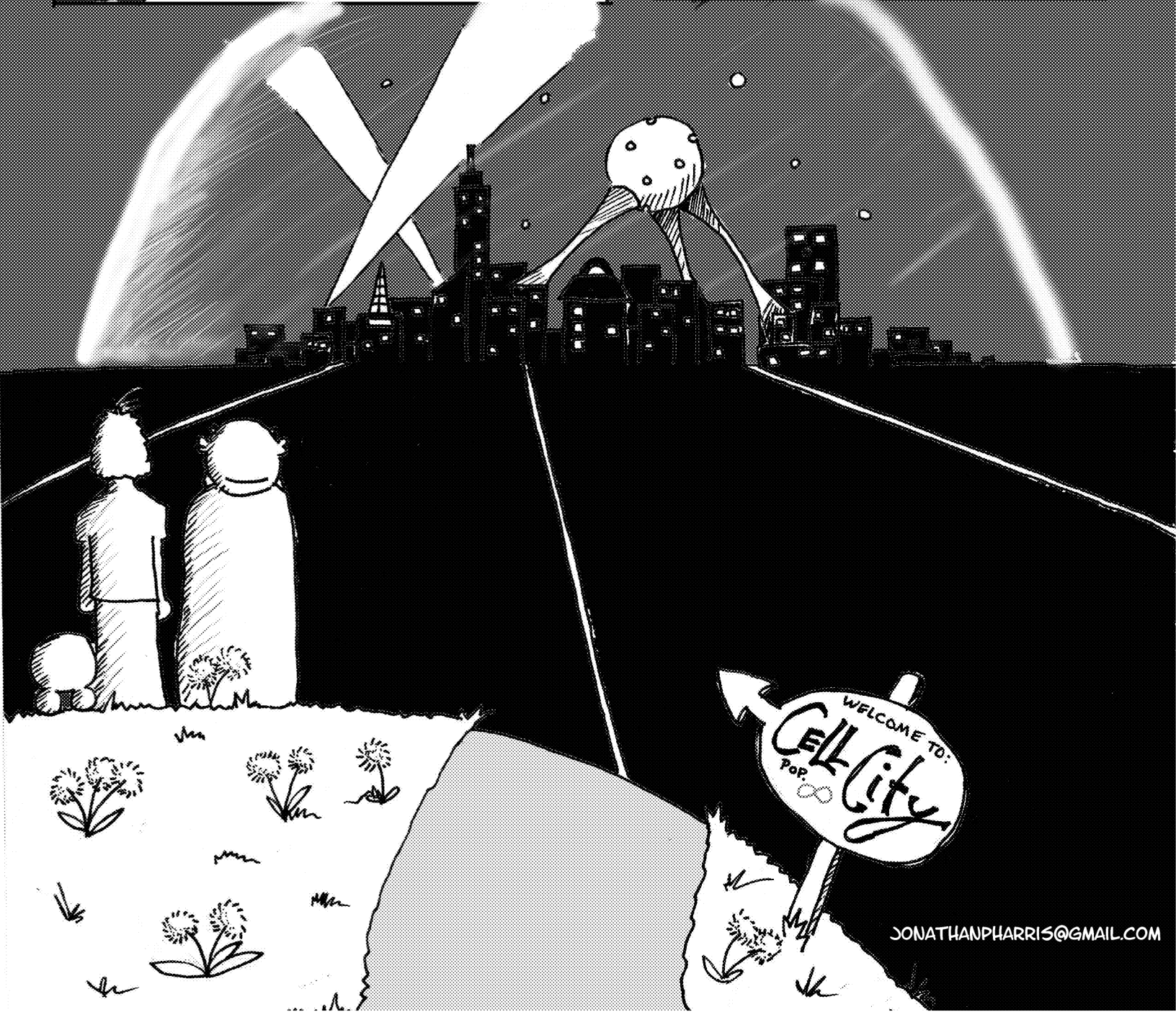
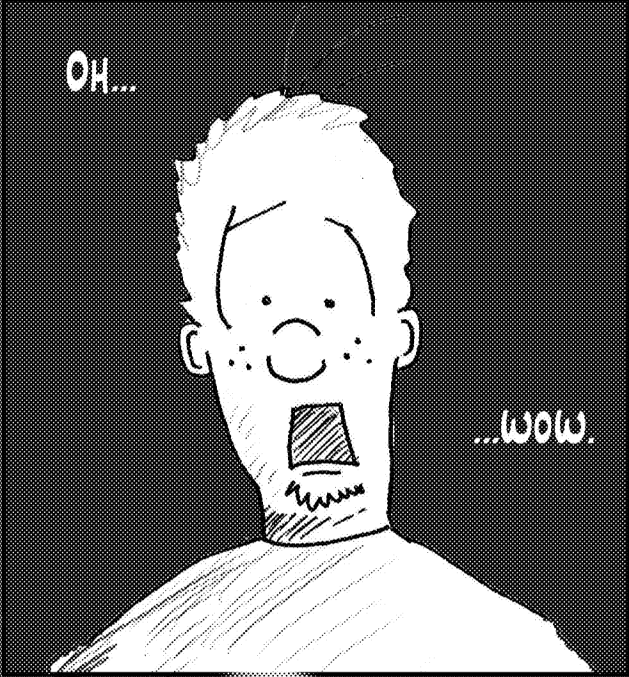
GASP! HOW MUCH FARTHER?

NOT MUCH.



OH...

...WOW.



## REVIEW

1. AN ATOM, OR THE SMALLEST PART OF AN ELEMENT, IS MOSTLY EMPTY SPACE. IN FACT, IF WE MADE AN ATOM THE SIZE OF A FOOTBALL STADIUM, THE NUCLEUS WOULD BE ABOUT THE SIZE OF A MARBLE SITTING IN THE CENTER, WITH A CLOUD OF WHERE ELECTRONS MIGHT BE BUZZING AROUND IT. DRAW AN ATOM WITH 2 PROTONS AND 2 ELECTRONS BELOW. IT DOESN'T NEED TO BE TO SCALE. LABEL THE PARTS.

2. IF THE ATOMIC WEIGHT OF OUR ATOM IS 4, HOW MANY NEUTRONS WOULD WE NEED TO ADD?

3. WHAT ELEMENT HAVE WE CREATED?

4. POTASSIUM (K) HAS AN ELECTRONEGATIVITY OF .82. ELECTRONEGATIVITY IS A MEASURE OF HOW MUCH AN ELEMENT "WANTS" ELECTRONS AND RANGES FROM ABOUT .7-3.8

IF WE COMBINED POTASSIUM WITH CHLORINE (ELECTRONEGATIVITY OF 3.16), WHAT TYPE OF BOND DO YOU THINK WOULD FORM? WHY?

5. WHAT ARE 2 OF THE PROPERTIES OF WATER THAT MAKE IT SO IMPORTANT FOR LIFE? WHY DOES IT HAVE THESE PROPERTIES?